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Studies on the Field Use of Potato True Seeds in Tuber Production[1]

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Abstract : Several cultural experiments were conducted to investigate the most adaptive method of using potato true seeds (TPS) in potato production.

1. Comparison between the use of true seeds and seed tubers.
2. Comparison of different seeding rates in relation to tuber yield.
3. Comparison of TPS tubers of different size in their ability as seed tubers.
4. Comparison of yielding ability of different TPS populations.

All plantings were adversely affected by extended period of heavy rainfall during the later part of the growth. However, results are summarized as follows :

1. All yields obtained from TPS seedling-whether by direct seeding or by transplanting, were lower than those obtained from tuber planting.
2. Potatoes produced from true seeds can be used as seed tubers to produce a crop as long as the tuberlets reach the size of 8g. The technology of direct seeding with dense spacing can be employed to produce numerous small tubers in limited land.
3. Direct seeding is more economic and labor-saving than transplanting in producing tubers.

To guarantee a successful crop of potatoes, it is essential to use healthy seed tubers. Various kinds of pathogens, especially viruses, are transmitted through otherwise diseased tubers to subsequent crop. Special technique and isolated area with very low population of aphids are usually required in the production of certified quality tubers. However, it is difficult for many tropical and subtropical countries to meet these requirements and to maintain a certified seed program. To compensate for this difficulty, an alternate system of potato production by the use of true seeds (in short, TPS) is being developed [1,2,3,4,5,9]. Freedom from tuber-borne diseases and high multiplication rate are expected in this new system. However, inherent problems needed to be overcome in this system are the low yield and wide segregation in TPS populations and the difficulty of efficient seed production [2,6,7,9,13]. The International Potato Center (CIP) in Peru has conducted researches in various aspects including genetics, physiology and agronomic management in attempt to promote the practical use of TPS in commercial potato production in different countries. New Zealand and Sri Lanka are experimenting the potato production from TPS [2,8]. The Republic of Korea is also reporting potato yield up to 40t/ha by the use of hybrid seeds [6]. During the past four years, the author has studied the TPS cultivation and found no commercial yield obtained from TPS populat-

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ions tested[11,12,13]. However, Yield increase was obtained when selected TPS tubers were used as seed tubers[11]。By the practice of transplanting, a fall crop of TPS seedling with 100 days of growth in field fits well to the current cropping system. The present study carried out during 1982 and 1983 was aimed to find the most adaptive method of using true seeds in potato production.

Materials and Methods

All four experiments were conducted in replicated plots (unless specifically stated, RCBD, 4 replicates) at Taiwan Agricultural Research Institute in Taichung area where the potato growing season extends from October to next February. Fields were prepared with in-corporation of little manure (water buffalo), after the second rice crop, into ridges ca. 0.7m wide on top and 12cm high. All TPS used were pretreated with GA (100 ppm) one or two days before sowing. All plantings were adversely affected by heavy rainfall starting in late January through March. Consequently all harvest was delayed till March and carried out in wet soil.

1. Comparison between the use of TPS and seed tubers.

To compare different propagating methods in their management and yieid, open-pollinated (op) seeds of 2 lines-No. 26 and No. 475 and tubers of 2 commercial cv. -Kennebec and Cardinal were used. True seeds were either directly sown in the field on October 30, 1982 with 5-6 seeds in holes opened 25cm apart on both sides of the ridges, or were grown in aluminum trays (60×45×10cm) in greenhouse for one month from November 7 and then transplanted with 2 seedlings per hill into field. On the same day of transplanting, tubers of 2 cultivars were planted. Field arrangement was split plot design with propagating methods as main plot and varieties as subplot, replicated 4 times. Each plot consisted of 100 hills.

2. Comparison of different seeding rates in relation to tuber yield.

Open-pollinated seeds of line 26 and line 475 were used to compare 3 different seeding densities in relation to the production of tuberlets which may be used as seed tubers. The number of seeds were calculated at 300, 200 and 150 corresponding to the seeding distance of 8×8, 10×10 and 12×12cm, respectively, and seeds were broadcast to plots of 0.7×2.8m on October 31, 1982. Fine soil and rice husk in that order were then broadcast to cover the seeds and reduce soil crusting. Careful watering was practiced till seedling had emerged.

3. Comparison of tuberlets of different size in their ability as seed tubers.

Preliminary study in greenhouse indicated that high seeding rate resulted in the production of may tiny tubers of 1 and 2g in size[11]. The tuberlets used in present study to find their effective size as seed tubers were of 4 open-pollinated and 2 hybrid populations (Table 4). Tuberlets were grouped into three, namely those of <5g, 5-10 g, and 10-15g and were randomly planted (CRD) with unequal replications. Each plot contained 40 tuberlets.

4. Comparison of yielding abilidy of different TPS populations.

Four open-pollinated and 5 hybrid TPS populations (Table 5) were used. All seeds were grown as seedlings in plastic trays of 60×35×6cm from November 12 to December 8, 1982 before they were transplanted to field. Each plot contained 100 hills of seedlings.

Results and Discussion

1. Comparison between the use of TPS and tubers.

Seedling emergence started to occur in 8 days of sowing in field. The percentage of germination counted by number of hills in 2 weeks was 75.7 and 72.0 for OP progenies of No. 26 and No. 475, respectively. However, leaf hopper and cutworm attacked the newly emerged seedlings and young seedlings, respectively and caused the reduction of seedling stands. These once slow-growing seedlings grew vigorously with quite uniformity in plant type after several cultivation and hill up. While seedlings grown in greenhouse and then transplanted to field had less vigor and fewer stems. Tubers of cv. Cardinal for planting were well-sprouted and soon emerged to fast-growing plants of which the haulm exceeded those of direct-sown seedlings in size in one and half month of planting. Tubers of cv. Kennebec were still in dormancy when planted and took longer time to emerge even with the pretreatment of GA. This gave Kennebec less time to grow before the incidence of rainfall. Growth from Kennebec was only comparable to that of field-seeded TPS. The yield from Kennebec was not considered to be representative. Different growth vigor in plants by different propagating practices was reflected by tuber yields. Highest yield was obtained by tuber-planted Cardinal as expected (Table 1). Tubers produced from TPS were less than 1/3 of those obtained from tuber-planted crops. Compared with the results obtained in previous study[11], tuber yields were markedly reduced in both tuber-planting and TPS plants due to unfavorable weather conditions occurred during tuber bulking. It also indicated that TPS seedlings were more vulnerable to adverse effect of unfavorable environment. The yield difference between direct sowing and transplanting was not significant (Table 1). Should the TPS seedling be given longer period of vegetative growth under optimum environment, the tuber yields might increase. Higher tuber production from TPS was usually obtained from plants with 5 months of growth in various countries[1,6]. However, this long period of growth in field also requires intensive pest and disease control.

Table 1. Tuber yields obtained through different propagating practices.

Propagation	Line	Yield (kg/100 hill)
Direct sowing[a]	26op	8.94 b[d]
	475op	8.84 b
Transplanting[b]	26op	3.57 b
	475op	3.60 b
Tuber-planting[c]	Cardinal	32.78 a
	Kennebec	5.30 b

a. TPS seeded in field : October 30, 1982. *b*. TPS seeded in greenhouse : November 7, 1982, transplanting : December 7, 1932.
c. Tuber-planting : December 7, 1982. *d*. Means do not have a letter in common are significantly different at the 5% level according to Duncan's multiple range test.

2. Comparison of different seeding rate in tuber yield.

All TPS started to germinate in 10 days of sowing. The emergence rates in 2 weeks, as shown in Table 2, were not significantly different among different seeding rates. Uniformity in both plant and tuber type was found in both OP populations. Tuber yield ranged from 10 to 17 kg per $10m^2$ (Table 3) which was much lower than the yield of 40-45kg obtained in Wiersema's study [14]. This might be partly due to the different TPS populations used and partly due to the low radiation occurring at the later part of the growth. The small plot size and the broadcast technique applied in this study resulted in uneven distribution of seedling stands which concentrated either in the center or on one side of the plot. The difference in tuber yield obtained from different seeding rate was not revealed. For the purpose of seed tuber production, however, the seeding space is suggested not to be wider than 10×10cm.

Table 2. Emergence rate of TPS lines in different seeding rates[a].

Line	Seeding rate	% of emergence
26op	8× 8cm	51.16
	10×10cm	46.00
	12×12cm	51.16
475op	8× 8cm	49.41
	10×10cm	44.75
	12×12cm	39.33

a. Direct seeding in field : October 31, 1932 ; harvest : March 7, 1982.

Table 3. Tuber yield and number of tubers over 10g in size of 2 TPS lines in different seeding rate[a].

Line	Tuber yield ($kg/10m^2$)			Avg.	No. of tubers>10g			Avg.
	8×8 cm	10×10 cm	12×12cm		8×8cm	10×10cm	12×12cm	
26 op	17.24	14.05	13.01	14.77	375	308	366	349
475 op	13.43	11.30	10.67	11.80	318	299	146	254

a. Direct seeding in field : October 13, 1982 ; harvest : March 7, 1983.

3. Comparison of TPS tubers of different sizes in their ability as seed tubers.

Many TPS tubers obtained from dense seeding in previous study [11] were of the size less than 5g. When planted as seed tubers, these tiny tubers, with one sprout, emerged later than those of larger size. Plants were mostly single stemmed and relatively small in size and tuber production was the lowest among all three tuber sizes tested (Table 4). The larger the size of seed tubers, the higher the potato yields were obtained, but the difference between using 5-10g or 10-15g was not significant. Different TPS populations showed differential response to the small seed tubers used as indicated by the much

more reduced yield in No. 83 op and Atzimba×R128.6 progenies from using seed tubers of less than 5g in size. To be usable as seed tubers, the TPS tubers are suggested to reach the size of ca. 8 g.

Table 4. Potato yields (kg/10m²) obtained by seed tubers[a] of different size.

Seed tuber size	TPS origin						Avg.
	83 op	26 op	401op	475op	Ax DTO-28[b]	A×R128.6[b]	
5g	1.00	4.41	3.65	5.50	1.88	0.56	3.13b[c]
5—10g	4.38	8.05	7.77	7.25	11.03	3.22	7.86a
10—15g	···	10.00	···	12.96	14.35	6.48	10.94a

a. TPS tubers obtained in Spring, 1982. *b*. A stands for Atzimba, seeds of both A×DTO-28 and A×R 128.6 were obtained from CIP. *c*. Means do not have a letter in common are significantly different at the 5% level according to Duncan's multiple range test.

4. Comparison of yielding ability of different TPS populations.

Differential growth vigor and plant type were shown among different TPS progenies during seedling stage in greenhouse. Average transplant survival was quite high if the seedlings were not suffered from cutworm damage which was later controlled by spraying Dursban. Treatment of Furadan or Temik was not effective in the control of this underground insect. Plants from PAS 3064, a hybrid seed population, gave the best growth and most vigorous haulm with thick main stems and broad leaves in the field. Population of PAS 1684, an open-pollinated progeny, gave the least uniform plants with many viney stems and small leaves. Highest yield was obtained from PAS 3064 with average production of 154 g per plant.

Table 5. Tuber yields obtained from different TPS progenies.[a]

TPS population	Seed source	Yield (kg/10 m²)
PAS[b] 1684	OP	2.45 cd[c]
PAS 2989	OP	2.03 d
PAS 3006	F 1	2.52 cd
PAS 3063	F 1	4.25 bc
PAS 3064	F 1	10.28 a
1282-17×1282-19	F 1	4.23 bc
1282-19×1282-17	F 1	6.01 b
No. 26	OP	5.57 b
No. 475	OP	4.59 b

a. TPS sown in greenhouse : November 12 ; transplanting : December 8, 1982. *b*. PAS stands for Pan-American Seed Co. where seeds are from. *c*. Means do not have a letter in common are significantly different at the 5% level according to Duncan's multiple range test.

Generally, TPS seedlings are more affected by environmental factors than tuber-planted plants are[2]. During the later part of the growing season in the present study, the incidence of continuons rainfall rendered the low yield of 200-300g per tuber-planted plant, and still lower production from TPS seedlings. Under normal conditions, yield of more than 500g is usually produced per tuber-planted plant. The heavy texture and low content of organic matter of the soil in experimental plots tended to give more adverse effect to the growth of TPS seedling than to that of tuber-planted crop. In conclusion, in order to facilitate the adoption of TPS technology in commercial production, it is necessary to screen for the adaptive and productive TPS. The selection may be enhanced or achieved sooner by testing a collection of as many as possible promising TPS populations from various countries. Direct seeding at close spacing would be more labor-saving than transplanting practice in the production of TPS tubers with size 5-10g in weight. This production method would eliminate the work of cutting tubers into seed pieces and the consequent disease infection, and would increase the multiplication rate. The recommended seedling density would be at 10×10cm spacing. To promote a uniform and fast germination, the TPS after pretreatment of GA for one day must be kept moist during and after sowing. An efficient sowing method needs to be explored to guarantee a uniform distribution of seedling stands. To shorten the storage period for the TPS tubers (as seed tubers), the most appropriate season for their production needs to be studied.

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利用種子生產馬鈴薯之栽培研究[1]

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摘 要

傳統的以種薯來繁殖馬鈴薯的栽培方法，因種薯感病常帶病原，必須在適當的隔離地區才能生產健康種薯，但種子則本身少帶病原，體積小，存放與運送均稱便，成本亦低，雖然由它生產馬鈴薯需時較用種薯者爲久，並會發生分離現象，但如選擇適宜親本，生產雜交種子，可以克服此缺點，另一方面如以種子育苗後再移植本田，又可縮短本田時間。若將由種子所生產的馬鈴薯當做種薯，供栽培之用，經此方法，每年採收種子栽種，即可每年更新種薯。本研究中進行了四項栽培試驗，一方面比較不同的種子族羣，期能尋選高產量的族羣，一方面探究適宜生產種薯的播種密度，但在植株生育中後期遇到連續陰雨，日照不足，使薯球產量與其乾物含量均偏低，以種薯栽植的 Kennebec 與 Cardinal 兩品種，單株產量均不足300公克，而實生苗所獲得的產量更低，部分試驗，表土甚淺，土質粘重，對於實生苗的不良影響也較顯著。綜合所得結果，認爲要廣集國外所研究欲推廣的種子，進行比較，可以較快速地選出適宜本省栽培的種子族羣，再進而生產該種子。種子經直播密植的方式，在小面積上即可生產許多小薯，這些薯球只要有近10公克重，即可做爲種薯，不但省去切薯工作，減少感染病害的機會，並可增加繁殖倍數，播種密度以10×10公分爲宜。在播種前，種子一俟經 GA 處理即應保持其潮濕狀態，若經 GA 處理又風乾才播種，出芽就會延緩好幾天。至於直播方式的選擇一撒播或點播，及爲縮短種薯所需冷藏時間的最適生產種薯時期，需另行探討。

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